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Managing carious lesions: Consensus recommendations on terminology

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Keywords:	Caries treatment, Operative dentistry, Restorative dentistry, Evidence-based dentistry/health care, Caries detection/diagnosis/prevention, Clinical practice guidelines

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Abstract:	<p>Variation in the terminology used to describe clinical management of carious lesions has contributed to a lack of clarity in the scientific literature and beyond. The International Caries Consensus Collaboration (ICCC), present issues around terminology, a rapid review of current words used in the literature for caries removal techniques and present agreed terms and definitions, explaining how these were decided.</p> <p>Dental caries is the name of the disease and the carious lesion is the consequence and manifestation of the disease; the signs or symptoms of the disease.</p> <p>The term dental caries management should be limited to situations involving control of the disease through preventive and non-invasive means at a patient level, whereas carious lesion management controls the disease symptoms at tooth level.</p> <p>Whilst it is not possible to directly relate the visual appearance of carious lesions' clinical manifestations to the histopathology, we have based the terminology around clinical consequences of disease (soft, leathery, firm and hard dentine). Approaches to carious tissue removal are defined. Selective Removal of Carious Tissue includes Selective Removal to Soft Dentine and Selective Removal to Firm Dentine. Stepwise Removal involves Stage 1 "Selective Removal to Soft Dentine" then Stage 2 "Selective Removal to Firm Dentine" 6-12 months later. Non-selective Removal to Hard Dentine was formerly known as "complete" caries removal (this technique can no longer be recommended).</p> <p>Adoption of these terms, around managing dental caries and its sequelae, will facilitate improved understanding and communication between researchers, within dental educators and the wider clinical dentistry community.</p>



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4 **Managing carious lesions: Consensus recommendations on terminology**

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Running title: Recommendations on terminology for carious tissue removal and caries management

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Abstract

Variation in the terminology used to describe clinical management of carious lesions has contributed to a lack of clarity in the scientific literature and beyond. The International Caries Consensus Collaboration (ICCC), present issues around terminology, a rapid review of current words used in the literature for caries removal techniques and present agreed terms and definitions, explaining how these were decided.

Dental caries is the name of the disease and the carious lesion is the consequence and manifestation of the disease; the signs or symptoms of the disease.

The term dental caries management should be limited to situations involving control of the disease through preventive and non-invasive means at a patient level, whereas carious lesion management controls the disease symptoms at tooth level.

Whilst it is not possible to directly relate the visual appearance of carious lesions' clinical manifestations to the histopathology, we have based the terminology around clinical consequences of disease (soft, leathery, firm and hard dentine). Approaches to carious tissue removal are defined. Selective Removal of Carious Tissue includes Selective Removal to Soft Dentine and Selective Removal to Firm Dentine. Stepwise Removal involves Stage 1 "Selective Removal to Soft Dentine" then Stage 2 "Selective Removal to Firm Dentine" 6-12 months later. Non-selective Removal to Hard Dentine was formerly known as "complete" caries removal (this technique can no longer be recommended).

Adoption of these terms, around managing dental caries and its sequelae, will facilitate improved understanding and communication between researchers, within dental educators and the wider clinical dentistry community.

Keywords: dental caries; excavation; minimally invasive dentistry; caries management

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83 **Introduction**

84 The International Caries Consensus Collaboration (ICCC), a group of 21 cariology experts
85 from 12 countries, met in Leuven, Belgium in February 2015 to discuss issues of relevance
86 to cariology researchers, dental educators and the clinical dentistry community. The goal
87 was to reach consensus on recommendations for managing carious lesions and the
88 terminology around this management, based on the best current scientific evidence, through
89 discussion and then consultation. In 2004, a series of papers related to the outcomes of an
90 International Consensus Workshop on Caries Clinical Trials (Pitts and Stamm 2004) were
91 published, their first goal being to "critically review modern caries definitions and
92 measurement concepts". Definitions, concepts and terminology as well as evidence to
93 support newer approaches for treating carious lesions, have advanced since then, and the
94 ICCC felt there was a need to clarify them based on available contemporary evidence and
95 expertise.

96 Dental caries is the name of a disease where an ecologic shift within the dental biofilm
97 environment, driven by frequent access to fermentable dietary carbohydrates, leads to a
98 move from a balanced population of micro-organisms (of low cariogenicity) to a high
99 cariogenic (more aciduric and acidogenic) microbiological population and to an increased
100 production of organic acids. This promotes dental hard tissue net mineral loss and results in
101 a carious lesion (Fejerskov et al. 2008).

102 This report from the ICCC, deals with the terminology around carious tissue removal, lays
103 out the background to the issues around terminology including a scoping review, and the
104 initial areas that were agreed to allow progression through the topic. We suggest a suite of
105 terms and definitions, based on current procedures and best evidence, explaining how these
106 decisions were made. The report defines generic dental caries terms (Table 1) where there
107 has been confusion, under the groupings of:

- 108 1) No removal of carious tissue;
- 109 2) Selective removal;
- 110 3) Stepwise removal; and
- 111 4) Non-selective removal of carious tissue.

112 One further aim is to make the nomenclature as future proof as possible by taking into
113 account the direction in which cariology is moving.

114 **Background**

115 150 years ago complete removal of all traces of carious tooth tissue within a carious lesion
116 was considered the gold standard, with the added "extension for prevention" tenet being

invoked to ensure that restoration margins were placed on areas of the tooth that are less vulnerable to caries. Advances in the field of cariology regarding the biofilm, together with improvement in materials, have challenged this perspective. There has been an evolution, gathering increasing speed over recent decades, away from removing all signs of carious tissue in a tooth, towards a more minimally invasive approach (Elderton 1993; Frencken et al. 2012; Banerjee and Domejean 2013). Indeed, the paradigm shift in carious lesion treatment, where it is appreciated that only infected and not affected dentine requires removal (Fusayama 1997) has occurred. Choices for managing a carious lesion cover a spectrum of options from complete surgical excision, where no part of the visible carious tissue is left in the tooth before a restoration is placed, to the opposite extreme, removing none of the carious tissue at all, and using non-invasive methods to prevent progression of the lesion (Ricketts et al. 2013; Green et al. 2015).

The alternatives to 'conventional complete caries removal' have been tested by different research groups over the last few decades through clinical trials and have been adopted, to varying degrees, as standard treatment by dental schools and clinicians in many countries (Innes et al. 2013; Frencken 2014; Kidd et al. 2015). However, there is inconsistency in the terminology for, and definitions that lie behind these approaches. These inconsistencies have developed naturally alongside the investigation of new interventions, and as a result of different research groups describing and naming interventions as they have been investigated. As is common in evolving fields of research, some of this research has taken place in parallel. Partly because of the sensitive nature of research development, but also simply as a result of a scarcity of opportunity for discussion, different terms have evolved. The lack of overt and planned communication within the research, teaching and clinical practice communities has resulted in some of the variations now seen in use of terminology and procedural definitions. For some procedures that seem to be very similar from the descriptions in research papers, different groups use distinctly different names. One particular definition of a procedure can have several names; for example, Franzon et al. (2014) used the term "one-step excavation" to describe an end result similar to that of Hesse's partial caries removal with "Excavation ... [to] ... hardened, dried dentin with a leathery consistency" (Hesse et al. 2011). Groups that work together may know what they are referring to, but the wider audiences can misinterpret what is being said – especially where a single word is used to designate a procedure, without further opportunity to describe what is being meant. Conversely, but leading to equally confusing scenarios, for procedures which seem to differ from their descriptions, the same name, or similar ones are used by different groups. So one name holds a variety of definitions. For example, with selective caries removal, Maltz et al. (2012) describes this as "Partial removal of the soft carious tissue from the cavity floor by hand excavator (only disorganized dentine was removed)"

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154 whereas Hesse and co-workers (2014), in their protocol step that involves partial caries
155 removal states that the “caries lesion [was] completely removed in the enamel/dentin
156 junction, and dentinal caries lesion partially removed with hand instruments until the dentin
157 started to become ‘firm and leathery’” and in the first stage of stepwise caries removal
158 Bjørndal et al. (2010) talk about “removal of the superficial necrotic and demineralized dentin
159 with complete excavation of the peripheral demineralized dentin, avoiding excavation close
160 to the pulp. When a temporary restoration could be properly placed no further excavation
161 was carried out, leaving soft, wet, and discoloured dentin centrally on the pulpal wall”.

162 To communicate successfully and concisely, researchers, clinicians and educators need to
163 use consistent terminology. This will help to ensure that carious tissue removal procedures
164 are described unambiguously. One example of a very clear description of technique in a
165 research study is found in the 10-year follow-up report of the seminal Mertz-Fairhurst and
166 co-workers’ ultra-conservative caries removal study where there were two control groups
167 with conventional restorations and one intervention arm where no soft dentine was removed.
168 “... We removed all of the crumbly, opaque demineralised enamel with a bur until we
169 reached translucent sound enamel. We did not remove undermined enamel or caries below
170 the bevel.... [we] observed shreds of carious dentin or other material hanging below the
171 bevel toward the soft and wet pulpal floor of the cavity. A layer of soft and wet-looking
172 dentine in the pulpal area of the cavity remained intact, and there was absolutely no
173 instrumentation below the enamel bevel.” (Mertz-Fairhurst et al. 1998).

174 Consistency, accuracy and precision are important for terminology to be used successfully,
175 which means there has to be standardisation globally. One of the crucial aspects of this
176 consensus work is that there is widespread dissemination and uptake, and to do this, there
177 has to be agreement that these are acceptable terms, across a broad range of communities
178 and groups. The cosmopolitan nature of the ICCC means that views have been represented
179 from 12 countries. To further assist with uptake of the terminology and its dissemination, we
180 are linking with the European Organisation for Caries Research (ORCA), the International
181 Association for Dental Research (IADR) Cariology Group and the American Dental
182 Education Association (ADEA) Cariology Section Sharing of expertise, experience and
183 joining with educational forums are part of the dissemination strategy to assist the ultimate
184 goal of uptake and use of the ICCC Terminology recommendations across the spectrum of
185 researchers, clinicians and educators.

186 **How much of a problem is the current terminology? (Scoping and consensus methodology)**

187 In a methodical search for systematic reviews comparing different methods of caries removal
188 (including partial caries removal, no caries removal etc.), seven systematic reviews were
189 identified (Griffin et al. 2008; Thompson et al. 2008; Hayashi et al. 2011; Ferreira et al. 2012;

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3 190 Ricketts et al. 2013; Schwendicke et al. 2013a; Schwendicke et al. 2013b). When these, and
4 191 the studies within them, were searched for the terminologies used to describe the various
5 192 carious lesion management strategies, 23 terms were found. These were circulated around
6 193 the ICCC group members, who were asked to contribute any further terms they knew were
7 194 used and 19 further unique new terms were added. This gave a total of 42 terms (see Table
8 195 2), a large number to describe essentially four different parts of the spectrum of carious
9 196 lesion removal/ management.

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14 197 The terms were circulated again, and this time the ICCC group was asked to choose up to
15 198 six terms that they felt were most representative of the full spectrum of options for carious
16 199 tissue removal. Eight different approaches to naming were returned together with comments.
17 200 These provided the basis for the discussions at the consensus meeting.

201 Initial areas agreed before proceeding

202 Dental caries and carious lesion

203 There was full agreement that 'dental caries' (or simply 'caries') and 'carious lesion' were not
204 interchangeable terms although they are often used as such.

205 There was consensus that dental caries (the pathological process) cannot be removed and
206 only carious tissues can be removed. An alternative way of viewing this is to consider that
207 the lesion can be stabilised, either by non-invasive, or by invasive means.

208 Although it is necessary to be exact and specify the definitions for 'caries' and 'carious', it is
209 worth noting that, in the English language, the pronunciation of these words makes them
210 sound almost identical. However, in other languages this may not be the case.

211 Dental caries management

212 The ICCC group considered two terms; "*caries management*" and "*carious lesion*
213 *management*". While the term *caries management* has been used historically in different
214 ways, often to include the restoration of teeth, it was agreed that it should be limited to
215 situations involving control of the disease through preventive and non-invasive means.
216 Therefore, caries management is a term to describe the actions taken at a patient level, i.e.
217 demineralisation and plaque/biofilm being managed not for one specific surface but for the
218 whole person e.g. plaque control/toothbrushing instruction, fluoride application, dietary
219 interventions and behaviour change techniques. Caries management aims to control the
220 disease and prevent a lesion becoming clinically manifest and for those lesions detectable
221 clinically, prevent their advancement.

222 What do we call the situation in which patient level *caries management* has failed? Consider
223 two specific situations where a carious lesion needs to be managed. Firstly, an active lesion

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that might require a non-invasive approach such as biofilm removal or, application of fluoride varnish to limit progression and secondly, where a lesion is not cleansable and is vulnerable to progression even in the presence of a full preventive program. In both of these cases, *carious lesion management* is aimed at controlling the symptoms of the disease at a tooth level. Of course, there is still a need for *caries management* to take place at a patient level in order to stem the source of the problem (the cause of the cause). However, for the purposes of this paper, *carious lesion management* means any procedure that involves doing something to an established, non-cleansable carious lesion to stop its progression. This might involve removing “none”, “some” or “all” of the carious tissues from a non-cleansable lesion.

Removal of carious tissues

The term *removal* was preferred to excavation, to avoid the synonymous link (in English) with hand excavation instrumentation and spoon excavators. It was agreed that the word *excavation* implied (albeit to a minor extent) that the process was inextricably linked to hand excavation of carious lesions, and could possibly limit the generalisability of the term.

Guiding principles of caries tissue removal

- The ICCC group agreed that the primary aim of carious tissue removal is:
- To retain the tooth and the health (sensitivity/vitality) of its pulp for as long as possible.
- The guiding principles of carious tissue removal are:
- Preservation of dental tissues;
 - Maintenance of pulpal health;
 - Avoidance of pulp exposure;
 - Avoidance of dental anxiety, (often considered particularly important in children but should be considered for all patients);
 - Provision of sound cavity margins to achieve a peripheral seal;

Complete removal of carious tissues

Through discussion, the group became aware that the term “*complete*”, when referring to removal of carious tissues, held different meanings for different people. Whilst within the group, this term was considered to mean “*removal until only leathery or firm dentine (resistant to hand excavator) is left pulpally*”, there was still a widely held belief that many still considered it to mean “*removal until only hard dentine is left pulpally*”. From the systematic reviews of the literature that were evaluated, the group considered removal of carious lesion to leave only hard dentine throughout the cavity to be over-treatment and involving removal

of tooth tissue that did not need to be removed (Thompson et al. 2008; Ricketts et al. 2013; Schwendicke et al. 2013a). It was also agreed that although the words “firm” and “hard” are subjective, they may still be the best terms available.

Terminology for approaches to carious tissue removal

In describing the clinical manifestations of caries, it would be ideal to relate the visual appearance directly to what is taking place histo-pathologically (Ogawa et al. 1983; Ngo et al. 2006; Wambier et al. 2007; Chibinski et al. 2013; Corralo and Maltz 2013). However, this is not straightforward. Histo-pathological micro- and ultra-structural investigations of the relationship between the visual appearance of carious tooth tissue and parameters such as bacterial invasion, degree of demineralisation, and softness of dentine etc. have been central to developing an understanding of the caries process. One historical example of misinterpretation of histo-pathology leading to over-excavation, was the belief that early lateral spread of demineralised dentine, undermining sound subjacent enamel, led to cavitation of enamel (Silverstone and Hicks 1985). To manage this clinically, early operative intervention was suggested, including the concept of the tunnel preparation (Wilson and McLean 1988). However, more recent research has clarified the structural inter-relations confirming that the spread of contaminated dentine is a *sequelae* of the clinically exposed dentine lesion (Bjørndal and Thylstrup, 1995; Ekstrand et al. 1998). The lateral contamination of dentine appears strictly related to stages of retrograde demineralisation of enamel (Bjørndal and Kidd 2005) i.e. demineralisation of the enamel originates at the enamel-dentinal junction as a result of bacterial metabolic activity within the dentinal lesion. Interestingly, the increasing use of clinical magnification technologies has led to these so-called ‘histo-pathological’ features being visible at the clinical level. Traditionally, these histological terms are less helpful when communicating to dentists in clinical settings and attempting to describe the degree to which carious tissues should be removed. In addition, it was felt that some of the terms such as “infected” were outdated and conveyed the idea that dental caries was a communicable disease. The terms shown in Figure 1, for the clinical (tactile) manifestations of carious dentine, were agreed and we have attempted to link the clinical consequences to the histological terms as far as possible. Table 1. expands on this by showing these agreed terms and their relationship to previously used terms.

Definitions for different clinical presentations of dentine (soft, leathery, firm and hard)

In material sciences, hardness can be characterised by the ability of a harder material to make a mark or to scratch a softer one. The force necessary to cause the scratch is also important. For practical purposes, a combination of these is probably the best way for the

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clinical dentist to determine how ‘soft’ or ‘hard’ dentine is and some guidance is given below to describe the physical properties that are associated with different states of dentine.

Soft dentine

Soft dentine will deform when a hard instrument is pressed onto it, and can be easily scooped up (e.g. with a sharp hand excavator) with little force being required.

Leathery dentine

Although the dentine does not deform when an instrument is pressed onto it, leathery dentine can still be easily lifted without much force being required. There may be little difference between leathery and firm dentine with leathery being a transition on the spectrum between soft and firm dentine.

Firm dentine

Firm dentine is physically resistant to hand excavation and some pressure needs to be exerted through an instrument to lift it.

Hard dentine

A pushing force needs to be used with a hard instrument to engage the dentine and only a sharp cutting edge or a bur will lift it. A scratchy sound or ‘cri dentinaire’ can be heard when a straight probe is taken across the dentine.

Definitions of approaches to carious tissue removal

Atraumatic Restorative Treatment (ART)

ART was agreed to mean a specific technique, which encompassed a mechanism for carious lesion management using hand instruments only, through removing soft, completely demineralised enamel and dentine until firm resistance is felt (See Selective Removal of Carious Tissue below). The cavity is then restored and available pits and fissures are sealed with an adhesive dental material, usually a high-viscosity glass-ionomer cement. For deep lesions (reaching into the inner pulpal 1/3 of dentine on radiograph) some soft carious tissue should be left on the pulpal wall to avoid pulp exposure. Therefore the decision to carry out selective removal to firm dentine or to soft dentine (see later) is related to cavity depth and the possibility of pulp exposure.

No Removal (no dentine carious tissue removal)

There are a variety of procedures where no dentine carious tissue removal takes place. Although diverse in the methods for carrying them out, these procedures effectively serve the same purpose – to control the carious lesion without removing any of the diseased

dentine tissue. The following techniques have been included under the “No carious tissue removal” banner.

Resin or Glass Ionomer Sealant Materials

Pit and fissure therapeutic sealant materials (resin or high-viscosity glass-ionomer cements) can be placed over enamel and dentine carious lesions. However, particularly with unfilled resin, mechanical properties are limited for filling and covering micro-cavities in enamel. There are also theoretical concerns about the materials’ abilities to resist forces occlusally when there is a considerable amount of soft dentine beneath the weakened enamel (the ‘trampoline’ effect). Therefore, the extent of the lesions where these materials can be used may be limited, pending evidence, to lesions that are confined (on a radiograph) to the outer $\frac{1}{3}$ of dentine.

The Hall Technique

This is a specific procedure for primary molars where a preformed metal (stainless steel) crown is fitted over the tooth to seal dentine carious lesions. The crown is cemented using glass ionomer cement, over a primary molar tooth and carious lesion with no tooth preparation or carious lesion removal. It is usually indicated for approximal lesions. The crown effectively seals the dentine carious lesion and slows down or prevents its progression to the dental pulp allowing the primary molar to exfoliate without pain or infection.

Non-Restorative Cavity Control

Other names for techniques (although each slightly different) that would be encompassed within this strategy include non-operative caries treatment and prevention (NOCTP) (Vermaire et al. 2014), non-restorative caries treatment (NRCT) (Lo et al. 1998; Gruythuysen 2010; Mijan et al. 2014) and slicing preparations.

This is a group of techniques that are broadly similar in that they aim to achieve arrest of a carious lesion using a package of care, through caries management at a patient level. They aim to prevent further loss of tooth tissue through caries progression in a cleansable cavity by successful instigation of an intensive preventive regimen that includes plaque removal through toothbrushing with a fluoridated toothpaste and/or application of fluoride varnish. From a carious lesion perspective, it may be necessary to alter the shape of the cavity by opening the cavity margins, to allow it to be cleansable and thus might involve some operative although not restorative intervention. These methods tend to be particularly applied to primary teeth but have a role in the permanent dentition, for example in root carious lesions.

358 Selective Removal of Carious Tissue

359 Terms used previously for non-selective and selective removal of carious tissues have
360 commonly included; ‘complete’ and ‘incomplete’ excavation of carious lesions. These
361 describe the result at the end of the carious tissue removal process. There are three
362 problems with these terms:

- 363 1. The criteria that demarcate the extent to which carious tissues are removed have not
364 been defined or agreed; should this be “free from bacteria”, “demineralised dentine”,
365 “discoloured dentine” or “soft dentine”?;
- 366 2. There are no commonly used and easily accessible technologies available to reliably
367 assess any of these criteria in a clinical setting, although it is acknowledged that this
368 might change in the future; and
- 369 3. If clinical assessments are re-evaluated using more advanced techniques
370 (measurement of bacterial load or mineral loss), based on the findings of previous
371 research, it is most likely that areas of dentine will be found where there is incompletely
372 removed carious tissue after attempted complete removal and vice versa.

373 Thus, we felt it made more sense to use procedural definitions to describe exactly what has
374 been *done* instead of measuring what we attempted to *achieve*. Using this rationale, the
375 group agreed on the term Selective Removal. In Selective Removal, different excavation
376 criteria are used when assessing the periphery of the cavity to the area in close proximity to
377 the pulp. The periphery of the cavity should be surrounded by ‘sound’ enamel to allow the
378 best adhesive seal. The peripheral dentine should be hard – with similar tactile
379 characteristics to sound dentine, such as a scratching noise when scraping the surface with
380 a sharp hand excavator or dental probe. However, firm carious tissue should be left towards
381 the pulpal aspect of the cavity, with enough of it removed to allow a durable bulk of
382 restoration to be placed, whilst avoiding pulp exposure. For deep lesions (extending beyond
383 the inner (pulpal) third or quarter of the dentine radiographically) Selective Removal should
384 be *to soft dentine* (the main aim is **not** to expose or irritate the pulp, provided that there are
385 no clinical symptoms of pulp inflammation present). For less deep lesions Selective Removal
386 should take place *to firm dentine* pulpally (this is likely to be necessary to allow adequate
387 depth for the restorative material bulk).

388 There were other reasons that the term Selective Removal was supported. The group
389 agreed there was an advantage to using terms that had not yet been used in the literature.
390 This was the case here where there were multiple terms for a single procedure used across
391 different groups and where the definition behind them was not clear. In addition, the negative
392 association of the terms “partial” and “incomplete”, which implied that the whole, required
393 treatment had not been carried out and that treatment was sub-optimal, were considered

disadvantageous in supporting the procedures' adoption and acceptance as standard techniques.

A description of these terms is found below.

Selective Removal to Soft Dentine

Selective Removal to Soft Dentine in deep lesions means leaving soft carious dentine in the pulpal aspect of the cavity. Peripheral enamel and dentine should be hard at the end of excavation to allow the best adhesive seal. This technique has previously been known as partial caries, one-step, ultra-conservative or incomplete caries removal. A sharp hand excavator can be used to check the softness/hardness of the remaining dentine, remembering that soft dentine will deform when an instrument is pressed onto it and little force would be required to lift it.

Selective Removal to Firm Dentine

In Selective Removal to Firm Dentine, the aim is to excavate to leathery or firm dentine (physically resistant to hand excavator) in the pulpal aspect of the cavity. This is the contemporary understanding of how much should be removed if the entire carious – CONTAMINATED but not the DEMINERALISED dentine, which can be remineralised, (Fig. 1) is aimed at being removed. It is acknowledged that there are not easily accessible or widely used means to tell when contaminated tissue has been removed and to determine when what is seen in the cavity is only demineralised dentine. However, although somewhat subjective, the tactile sense of reaching *firm* dentine on the pulpal floor rather than aiming for *hard* dentine is probably the best guide that can be given.

Stepwise Removal

Certain terms were felt to be in fairly common use, had less variability in their definition and understanding and were well accepted. It was therefore considered to be advantageous to adopt these as standard with just a clear and unambiguous explanation of the definition behind them. This was the case for Stepwise Removal (Bjørndal et al. 1997; Bjørndal and Larsen, 2000; Paddick et al. 2005).

Stepwise Removal involves "Selective Removal to Soft Dentine" at Stage 1, followed 6-12 months later by "Selective Removal to Firm Dentine" for Stage 2

Stage 1 has the same carious tissue removal aims as "Selective Removal to Soft Dentine" with completely demineralised carious tissue, still soft, being left pulpally but where there is removal of enough carious tooth tissue to place a durable restoration whilst avoiding pulp exposure. The periphery of the cavity should be hard – with similar appearance and tactile characteristics to sound dentine. A provisional restoration is placed with a restorative

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material that is considered suitable to last for up to 12 months. The subsequent removal of this provisional restoration should then be followed by the “Selective Removal to Firm Dentine” pathway with placement of a definitive restoration aiming for longevity. This technique has previously been also known as “two-step excavation”.

Non-selective Removal to Hard Dentine

Non-selective Removal to Hard Dentine was formerly known as ‘complete excavation’ or ‘complete caries removal’ and is no longer recommended as an approach for carious tissue removal. It is only mentioned here for completeness. It is the approach to carious tissue removal that was accepted in the past and is now considered over-treatment. The aim was to remove soft carious tissue to reach hard dentine resembling healthy dentine in all parts of the cavity, including pulpally. For the pulpal area, Bjørndal describes ‘complete caries excavation’ as “leaving only central yellowish or greyish hard dentin (equal to the hardness of sound dentin, as judged by gentle probing).” (Bjørndal et al. 2010).

However, for deep caries lesions (reaching into the inner pulpal 1/3 of dentine on radiograph), ‘complete caries excavation’ is now considered likely to result in detriment to the tooth through exposure of the pulp, indirect damage to the pulp from irritation passing through the thin remaining dentine thickness or from weakening the tooth’s structural integrity unnecessarily (Ricketts et al. 2013; Schwendicke et al. 2013a). This approach is no longer recommended. However, for shallow carious lesions (involving the outer pulpal third of dentine on radiograph), Non-selective Removal to Hard Dentine may not be much different from Non-selective Removal to Firm Dentine.

Summary

We have presented here a comprehensive list of terms to encompass the full spectrum of carious tissue removal options following a process of consensus and consultation. However, other areas remain where there is no standardised terminology or where there are subjective terms that are commonly used such as ‘invasive’, ‘restorative’ and ‘intervention’ and we have had to resort to using some of these here and in the parallel paper to this one on recommendations for managing carious lesions (Schwendicke et al. 2016). These will perhaps form the next stage of standardisation but in the meantime there is a need to facilitate dissemination – this is an inextricable and essential component of consensus within the specialty if the advantages of the consensus terminology are to be maximised.

Declaration of Interests

The corresponding author formally requested a declaration of possible conflicts of interest from each of the consensus conference members. We declare there were no commercial conflicts of interest within the consensus process and writing of this document and no

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Authors contribution

Initiated and organized the consensus process: JF, FS, NI

Prepared abstracts for the meeting and held presentations: LB, MM, DM, DR, KvL, FS

Contributed to the workshop and the consensus process before and after the workshop: all authors.

Wrote the initial draft of the manuscript: NI, JF, FS

Read, amended and approved the manuscript: all authors.

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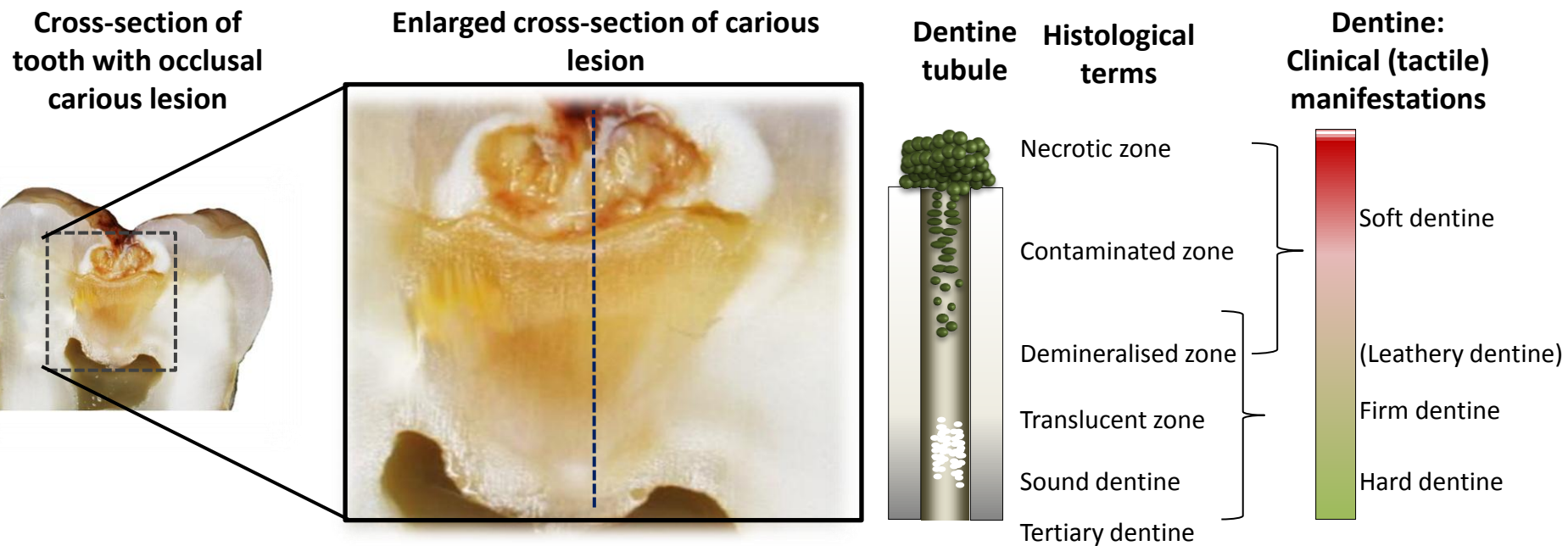


Figure 1. Diagrammatic representation of the carious lesion (after Ogawa et al. 1983)

1 Table 1. Overview of carious tissue removal/management terminology and groupings

Type of carious tissue removal	Previous names/further detail	Short descriptions	Indications for non-cleansable dentine carious lesions
Atraumatic Restorative Treatment (ART)	A specific technique for carious lesion management using hand instruments only	<ul style="list-style-type: none">- Carious tissue removal using hand instruments only.- Pulpally; excavate to firm dentine in shallow lesions and to soft dentine in deep lesions.- Restore cavity and seal available pits and fissures with adhesive dental material, usually a high-viscosity glass-ionomer cement.	Primary & permanent teeth Shallow and moderate [†] dentine carious lesions to allow adequate depth for a durable restoration
No removal		<ul style="list-style-type: none">- No dentine carious tissue removal.	
Fissure sealant including 'ART sealants' (therapeutic)		<ul style="list-style-type: none">- Fissure sealants, place sealants (resins) or glass-ionomer cement over clinically intact enamel or enamel with signs of early breakdown. This can also be suitable where there is a micro-cavitation but the material is considered to have adequate mechanical properties to bridge any enamel breaches.	Primary & permanent teeth Shallow and moderate [†] carious lesions that appear non-cavitated clinically, radiographically they might extend into dentine.
Hall Technique		<ul style="list-style-type: none">- Preformed (stainless steel) crown is cemented over the primary molar tooth to seal dentine carious lesions	Primary teeth Moderate [†] and deep* non-cavitated and cavitated proximal carious lesions, radiographically – 'clear' band of dentine between carious lesion and pulp. Permanent teeth Not indicated.
Non-Restorative Cavity Control	Non-Restorative Caries Treatment, Non-Operative Caries Treatment and Prevention, Slicing Technique	<ul style="list-style-type: none">- Cavitated dentine carious lesions are transformed to cleansable forms that can be cleaned by the patient or parent/carer with a toothbrush.- May or may not be supported by regular fluoride varnish application or placement of glass-ionomer based material.	Primary & permanent teeth Cavitated dentine carious lesions that can be made cleansable; might not be restorable (for permanent teeth, might also be suitable for root surface caries).
Selective Removal to Soft Dentine	Partial, incomplete, minimally invasive or ultraconservative caries removal	<ul style="list-style-type: none">- Pulpally; remove carious tissue until soft dentine is reached.- Enough tissue is removed to place a durable restoration avoiding pulp exposure.- Periphery of cavity; clean to hard dentine (similar to sound dentine).	Primary & permanent teeth Deep carious lesions*.
Selective Removal to Firm Dentine	Partial caries removal, minimally invasive or incomplete caries removal	<ul style="list-style-type: none">- Pulpally; remove carious tissue until leathery or firm dentine (resistant to hand excavator) is reached.- Periphery of cavity; clean to hard dentine (similar to sound dentine).	Primary & Permanent teeth Shallow and moderate dentine carious lesions [†] to allow adequate depth for a durable restoration.
Stepwise Removal	Stepwise caries removal, Stepwise excavation, 2-step caries removal	<ul style="list-style-type: none">- Pulpally; Selective Removal to Soft Dentine during 1st step – remove carious tissue until soft dentine is reached.- Enough tissue is removed to place a durable restoration avoiding pulp exposure.- Periphery of cavity; clean until hard dentine is reached (similar to sound dentine). <i>Subsequently (6-12 months)</i>- Pulpally; Selective Removal to Firm Dentine and place a long-term restoration.	Primary teeth Not indicated – use Selective Removal to Soft dentine. Permanent teeth Deep carious lesions*.
Non-selective to Hard Dentine (not advocated)	Complete caries removal	<ul style="list-style-type: none">- Pulpally & cavity periphery; carious tissue removal aims to remove all demineralised dentine to reach hard dentine, leaving no softened dentine.- Considered over-treatment	Primary & permanent teeth <u>Not advocated.</u>

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3 [†]Shallow and moderate lesions involving the outer pulpal two thirds or three quarters of dentine radiographically, or where there is no risk
4 of pulp exposure
5 ^{*}Deep = radiographically involving the inner pulpal third or quarter of dentine, or with clinically assessed risk of pulpal exposure

Table 2. The 42 Individual terms for carious tissue removal/management techniques derived through structured literature searching and consultation within the ICCC.

Arrestment of caries lesion in dentin	Non-restorative caries treatment
ART	Non-restorative therapy
Atraumatic restorative treatment	Non-surgical caries management
Caries control achieved	One step complete caries removal
Complete caries removal	One-step incomplete excavation
Complete excavation	Partial caries removal
Conservative treatment of deep caries lesions	Partial excavation
Incomplete caries removal	Sealing in caries lesion
Incomplete excavation	Sealing-in caries
Indirect pulp cap	Sealing-in caries "using restorative materials/techniques" (resins, crowns, etc)
Minimally invasive caries removal	Sealing-in caries using "non-restorative caries treatment" (e.g., sealants, infiltration)
Minimally invasive indirect pulp therapy technique	Selective
Minimally invasive operative approach	Selective excavation
Minimally invasive operative caries management	Stepwise
Minimum intervention dentistry	Stepwise caries removal
No caries removal	Stepwise excavation
No dentinal caries removal	Surgical
Non-invasive management of caries lesions	Two-step complete excavation
Non-mechanical removal of carious tissue	Two-step incomplete excavation
Non-operative caries treatment and prevention	ultra-conservative treatment (cleaning sizable cavities with brush and paste in primary teeth) and small cavities restored with ART
Non-operative management of caries lesion (arrest of caries lesion)	Unselective